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May 14, 1981

United States Nuclear Regulatory Commission
Washington, D.C. 20555

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U.S. NUCLEAR REGULATORY COMMISSION

Attention: Mr. Edward J. Butcher, Jr.
Project Officer

Reference: FRC Project C5257
NRC Contract NRC-03-79-118
NRC TAC No. 10180
FRC Task No. 190
Title: FRC TER: Override and Reset of Control Circuitry in the Ventilation/Purge Isolation and Other Engineered Safety Feature Systems - Duane Arnold Energy Center

Dear Mr. Butcher:

Enclosed is a Technical Evaluation Report which reviews the override and reset control circuitry in the ventilation/purge isolation system and other engineered safety feature systems of the Duane Arnold Energy Center nuclear power plant.

The report includes a description of the criteria established by NRC for the review, an evaluation of the specified systems for compliance with the stated criteria and conclusions drawn by FRC.

Very truly yours,

S. P. Carfagno

S. P. Carfagno
Project Manager

SPC/JS/ih

cc: K. R. Wichman
J. T. Beard

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TECHNICAL EVALUATION REPORT

OVERRIDE AND RESET OF CONTROL CIRCUITRY IN THE VENTILATION/PURGE ISOLATION AND OTHER ENGINEERED SAFETY FEATURE SYSTEMS

IOWA ELECTRIC AND POWER COMPANY
DUANE ARNOLD ENERGY CENTER

N[illegible] DOCKET NO. 50-331

NRC TAC NO. 10180

NRC CONTRACT NO. NRC-03-79-118

FRC PROJECT C5257

FRC TASK 190

Prepared by

Franklin Research Center
The Parkway at Twentieth Street
Philadelphia, PA 19103

Author: J. E. Kaucher

FRC Group Leader: J. Stone

Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: J. T. Beard

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ABSTRACT

This report documents the technical evaluation of the design of electrical, instrumentation, and control systems provided in the Duane Arnold Energy Center to initiate automatic closure of valves to isolate the containment. The evaluation was conducted in accordance with NRC criteria, based on IEEE Std 279-1971, for assuring that containment isolation and other engineered safety features will not be compromised by manual overriding and resetting of the safety actuation signals. It was concluded that the electrical, instrumentation, and control systems in Duane Arnold Energy Center partially conform with the NRC criteria.

FOREWORD

This report is supplied as part of the Review and Evaluation of Licensing Actions for Operating Reactors being conducted by Franklin Research Center (FRC) for the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, Division of Licensing.

The work was performed by FRC, Philadelphia, PA, under NRC contract No. NRC-03-79-118.

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1. INTRODUCTION

Several instances have been reported at nuclear power plants in which the containment ventilation/purge valves would not have automatically closed when required because the safety actuation signals were either overridden or blocked during normal plant operations due to procedural inadequacies, design deficiencies, and lack of proper management controls. These instances also brought into question the mechanical operability of the containment isolation valves themselves. The U.S. Nuclear Regulatory Commission (NRC) judged these instances to be Abnormal Occurrences (#78-5) and were, accordingly, reported to the U.S. Congress.

As a follow-up on these Abnormal Occurrences, the NRC staff is reviewing the electrical override aspects and the mechanical operability aspects of contain- ment purging for all operating power reactors. On November 28, 1978, the NRC issued a letter entitled "Containment Purging During Normal Plant Operation" [1]* to all boiling water reactor (BWR) and pressurized water reactor (PWR) licensees. In a letter dated January 3, 1979 [2], the Iowa Electric Light and Power Company (IEL), the Licensee for Duane Arnold Energy Center (DAEC), replied to the NRC generic letter. On August 31, 1979 [3], IEL provided additional information pertaining to the NRC generic letter. On March 28, 1980 [4], the NRC requested that the Licensee provide additional information concerning electrical bypass and reset of engineered safety feature (ESF) signals for DAEC. IEL made a partial response on May 5, 1980 [5], which addressed only the containment purge valve electrical design, and submitted a supplement on June 17, 1980 [6], which analyzed their system in terms of the NRC criteria for ESF equipment and presented electrical schematics, system diagrams, and electrical data to verify compliance.

The present technical evaluation report, which reviews the IEL documentation deals only with the design of the DAEC electrical, instrumentation, and control (EI&C) components of the containment ventilation isolation (CVI) and other engineered safety features.

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*Numbers in brackets refer to citations in the list of references, Section 4.

2. EVALUATION

2.1 REVIEW CRITERIA

The primary intent of this evaluation is to determine if the following NRC staff criteria are met for the safety signals to all ESF equipment:

- Criterion 1. In keeping with the requirements of General Design Criteria (GDC) 55 and 56, the overriding* of one type of safety actuation signal (e.g., radiation) should not cause the blocking of any other type of safety actuation signal (e.g., pressure) for those valves that have no function besides containment isolation.

- Criterion 2. Sufficient physical features (e.g., key lock switches) are to be provided to facilitate adequate administrative controls.

- Criterion 3. A system-level annunciation of the overridden status should be provided for every safety system impacted when any override is active. (See NRC Regulatory Guide 1.47.)

Incidental to this review, the following additional NRC staff design criteria were used in the evaluation:

- Criterion 4. Diverse signals should be provided to initiate isolation of the containment ventilation system. Specifically, containment high radiation, safety injection actuation, and containment high pressure (where containment high pressure is not a portion of safety injection actuation) should automatically initiate CVI.

- Criterion 5. The instrumentation and control systems provided to initiate the ESF should be designed and qualified as safety-grade equipment.

- Criterion 6. The overriding or resetting+ of the ESF actuation signal should not cause any valve or damper to change position.

In this review, Criterion 6 applies primarily to other related ESF systems, because implementation of this criterion for containment isolation has been reviewed by the Lessons Learned Task Force, based on the recommendations in NUREG-0578, Section 2.1.4. Automatic valve repositioning

*Override: the signal is still present, and it is blocked in order to perform a function contrary to the signal.

+Reset: the signal has come and gone, and the circuit is being cleared in order to return it to the normal condition.

upon reset may be acceptable when containment isolation is not involved. The acceptability of repositioning upon reset will be determined on a case-by-case basis. Acceptability will be dependent upon system function, design intent, and suitable operating procedures.

2.2 CONTAINMENT VENTILATION SYSTEM DESIGN DESCRIPTION

2.2.1 Generalized System Design

The Licensee has indicated that "The circuitry for the Duane Arnold Energy Center (DAEC) safety systems was designed in accordance with IEEE Standard 279-1968 or 1971, depending upon the time of design and the version of the standard which governed" [6]. Also, recent modifications have been made to the containment ventilation system control circuitry in order to comply with the six NRC criteria.

2.2.2 Logic Circuits for Reset, Seal-in and Trip

The DAEC design consists of two ESF trains, identified as the primary containment isolation system (PCIS), which can cause isolation of the containment purge and vent systems. Train A controls the inboard containment purge and vent isolation valves, and Train B controls the outboard purge and vent isolation valves. Each train is powered by a different electrical bus. The isolation signals for each train are:

1. Automatic Isolation Signals

   a. high reactor building exhaust radiation (1 of 1)
   b. high fuel pool exhaust radiation (1 of 1)
   c. high drywell pressure (2 of 2)
   d. low reactor water level (2 of 2)

2. Manual Isolation

   No system level manual isolation is provided. Manual isolation is accomplished via manual switches for individual purge and vent valves.

Trip relays associated with each isolation parameter operate contacts, arranged in series-parallel configuration (Figure 1), to provide power to two slave relays (K23/K24 and K63/K61) in each train via a seal-in relay (K23/K24) contact paralleled by a momentary reset switch contact. The slave relays, when energized, close contacts in the individual valve control circuits in series with the local control switch and solenoid, allowing purge and vent isolation valves to be opened. A contact from one of the slave relays in each train performs the seal-in function. Trip relay contacts are paralleled with parameter override contacts that are operated from a keylock-controlled switch provided for each isolation parameter. Each of these switches also actuates an annunciator circuit to indicate that a specific protection signal has been bypassed.

On system startup, with slave relays deenergized and all trip parameters below their setpoint, momentary closure of the circuit reset contact will energize the slave relays which, in turn, will complete the seal-in circuit around the reset contact and close contacts in series with associated pilot solenoids.

When the level of an isolation parameter exceeds its setpoint, power to the slave relays is interrupted via the trip logic network. The slave relays are deenergized and both seal-in and valve control circuitry slave relay contacts are opened. Slave relays can be reenergized following a trip signal, only after all signals are cleared or individually bypassed and the reset switch manually positioned.

2.2.3 Individual Valve Control Circuits

The torus and drywell, inboard and outboard, vent and purge valve control circuits (Figure 2) receive power from the output of the trip logic network (i.e., these control circuits are in parallel with the slave relays). Consequently, the pilot solenoids for these valves may be energized only when all trip signals are cleared or bypassed (the same condition required for slave relay energization). In addition, slave relay contacts are provided in series with each valve operator pilot solenoid.

The control circuit for each vent and purge valve also includes a three position (close-auto-open), spring return to auto, control switch. There are two sets of switch contacts (open and close) in each valve control circuit. The opening contacts are series contacts paralleled by seal-in contacts, which are closed when the pilot solenoid auxiliary relay is energized. The closing contacts are in series with the pilot solenoid and auxiliary (seal-in) relay.

With the valve control logic circuit energized, the slave relay contacts in each valve control circuit are shut. The valve(s) may now be opened by momentarily placing the particular valve control switch in the "open" position. This causes the valve opening contacts to close, energizing the pilot solenoid and auxiliary relay which, in turn, closes the seal-in contacts. The valve will then remain open until either the valve control switch is placed in the "closed" position or an isolation signal is received.

The individual valve control circuits for the torus and drywell vent bypass valves (Figure 1) are the same as those for the torus and drywell purge and vent valves. These valve control circuits may, however, receive power from either the output of the trip logic circuit or directly from AC control power, bypassing the trip logic network. When this bypass mode of power supply is selected, only one of the two, torus or drywell, bypass valve control circuits can be supplied power at one time, depending on the position of the bypass switch. Since slave relay contacts in the individual valve control circuit are connected in series with the pilot solenoid, neither the pilot solenoid nor the valves can be opened when the slave relays are deenergized (i.e., a trip signal exists and is not bypassed).

The valve control circuits for the torus and drywell nitrogen makeup valves (Figure 2) are the same as those for the vent and purge valves with the addition of series contacts which open when the drywell pressure is greater than 1 psig. These contacts provide automatic control of nitrogen inerting the containment.

The valve control circuits for the purge to recirculating seal valves (Figure 2) receive power from upstream of the trip logic network. For these valves, the slave relay contacts operate in a valve permissive circuit in lieu of directly activating contacts in the valve control circuits. The valve permissive relay is in series with two sets of reactor low-low water level contacts, a parallel circ. . providing reset and seal-in contacts, and the slave relay contacts. The permissive relay contacts in the purge to recirculating seal valve control circuits operate in series with the valve pilot solenoid/seal-in relay and the parallel configuration of manual switch/seal-in relay contacts.

2.3 CONTAINMENT VENTILATION SYSTEM DESIGN EVALUATION

No instances were found where the overriding of one type of safety actuation signa (e.g., drywell high pressure) causes the blocking of any other type of safety actuation signal (e.g., reactor low level) for those valves that have no function besides containment isolation. Therefore, it was concluded that NRC staff Criterion 1 has been satisfied in the PCIS at DAEC.

Override switches provided (GE Model CR2940 Form UN200D) are keylock-type switches and will support adequate administrative controls. Therefore, it was concluded that NRC staff Criterion 2 has been satisfied in the PCIS at DAEC.

Each override switch provides one contact which energizes an amber light in the control room to display the bypass condition to the operator for each individual trip parameter when the switch is placed in the override position. Also, the four override switches in each division of isolation logic are connected to a common annunciator window in the control room, such that any one of the four key switches placed in the override position results in an alarm which requires operator acknowledgment. Therefore, it was concluded that NRC staff Criterion 3 has been satisfied in the PCIS at DAEC.

The four isolation parameters listed in Section 2.2 will automatically initiate containment ventilation isolation. However, there is no radiation detector that monitors the primary containment atmosphere. The two radiation detectors which initiate PCIS monitor the fuel pool area and the reactor building. Therefore, Criterion 4 is not satisifi...

The Licensee has indicated that the instrumentation and control systems, including detectors, provided to initiate the PCIS are designed in accordance with IEEE Std 279 and use Seismic Category I equipment. Therefore, NRC staff Criterion 5 is satisfied in the PCIS at DAEC.

The overriding or resetting of any actuation signal will not cause any valve or damper to change position. This is accomplished by the use of seal-in relays and contacts at the equipment level and also by the provision of reset and override controls at the accident parameter level. Therefore, it was concluded that NRC staff Criterion 6 has been satisfied in the PCIS at DAEC.

2.4 OTHER ENGINEERED SAFETY FEATURE (ESF) SYSTEM CIRCUITS

To provide a complete evaluation of the ESF system circuits, a general review of all ESF system circuits and an in-depth review of the circuit for the residual heat removal (RHR) system was conducted.

2.4.1 Description of RHR System Design

Initiation signals, Phase A and Phase B, are provided for all RHR engineered safety feature equipment on each of two separate electrical trains, A and B. Each train consists of automatic inputs processed through relay logic circuitry to actuate a relayed logic component actuation system. The initiation signals for each electrical train are arranged to provide automatic initiation upon either of the following signals:

1. High drywell pressure (1 of 2 taken twice)
2. Reactor low water level (1 of 2 taken twice)

The contacts from the control functions are in an "or gate" configuration and the logic circuit is provided with a seal-in relay (K9) and contact as well as a reset control (Figure 3).

Individual pump and valve control circuits have both manual and automatic control schemes for start-stop or open-close as well as an indication for run status or position.

2.4.2 Evaluation of Other ESF Systems Design

2.4.2.1 RHR System

No instances were found where the overriding of one type of safety actuation signal causes the blocking of any other type of safety actuation signal for those valves that have no function besides containment isolation. However, ten ESF actuated valves (MO-2000, MO-1902, MO-2005, MO-1932, MO-2007, MO-1934, MO-2006, MO-1933, MO-2001, and MO-1903), which have functions in addition to containment isolation, are provided with control circuitry that allows the bypassing of automatic ESF actuation (see Figures 4 and 5). These valves are normally shut on RHR automatic initiation. They may be opened through the use of two or three manual switches, a local keylocked control switch (42/CS, Figure 5), and either S17 or S17 and S18 (keylocked) depending on the presence of an automatic intiation signal and low reactor vessel shroud level (see Figure 4). Following these manual actions, the automatic initiation of RHR will not cause these valves to close. Although not a literal violation of Criterion 1, this situation has been identified for NRC staff evaluation with respect to acceptability.

Two of the three switches required to bypass the RHR valves identified above (S18 and local control switches) are keylock-type switches and will support adequate adminstrative controls. In addition, system level annunuciation of this condition is provided. Consequently, Criteria 2 and 3 are satisfied for these ten valves. Criteria 2 and 3 do not apply to other RHR valves.

Criterion 4 does not apply to the RHR system.

The Licensee has indicated that the instrumentation and control systems provided to initiate the RHR system are designed in accordance with IEEE Std 279 and use Seismic Category I equipment. Therefore, NRC staff Criterion 5 is satisfied in the RHR system at DAEC.

The overriding or resetting of any RHR actuation signal will not cause any valve or damper to change position. Therefore, it was concluded that NRC staff Criterion 6 has been satisfied in the RHR system at DAEC.

2.4.2.2 Other ESF Systems

Equipment level bypasses are provided for several equipment items at DAEC which, if actuated following one safety actuation signal, will prevent a second safety actuation signal from causing the equipment to take its post-accident position. This equipment, however, serves functions other than containment isolation. These valves are identified below:

a.	Reactor Water Sample Valve	(Inboard)	SV-4639
b.	Reactor Water Sample Valve	(Outboard)	SV-4640
c.	N_2 Supply Isolation Valve	(Inboard)	SV-4371B
d.	N_2 Supply Isolation Valve	(Outboard)	SV-4371A
e.	Loop A Containment Atmosphere Monitor System Isolation Valve		SV-8101A to SV-8110A
f.	Loop B Containment Atmosphere Monitor System Isolation Valve		SV-8101B to SV-8110B

Although not a literal violation of Criterion 1, this situation has been identified for NRC staff evaluation with respect to acceptability.

Operation of these bypasses is controlled by keylock switches and their activation is annunciated. Consequently, NRC staff Criteria 2 and 3 are satisfied for these eight valves.

Criterion 4 does not apply to ESF valves other than PCIS valves.

The Licensee has indicated that the instrumentation and control systems are designed in accordance with IEEE Std 279 and use Seismic Category I equipment. Therefore, Criterion 5 is satisfied.

Several equipment items not related to the PCIS or RHR systems will, as currently designed, move to their normal, pre-accident, position upon safeguard signal reset. DAEC has provided proposed modifications to these control circuits (Attachment 3 to Reference 6) which will, when implemented during the 1981 refueling outage, prevent such repositioning upon reset. FRC has reviewed these system modifications and concurs that following their implementation Criteria 6 will be satisfied. The valves which move to their normal, pre-accident, position upon safeguard signal reset are:

a. Reactor Recirculation Pump Discharge Bypass Valve (MO-4629)
b. Reactor Recirculation Pump Discharge Bypass Valve (MO-4630)
c. Auto Depressurization Valve (SV-4400)
d. Auto Depressurization Valve (SV-4402)
e. Auto Depressurization Valve (SV-4405)

f. Auto Depressurization Valve (SV-4406)
g. HPCI Gland Seal Condenser Vacuum Pump (IP-233)
h. Steam Line Drain Isolation Valve (outboard) (SV-2212)
i. Consensate Pump Discharge Isolation Valve (SV-2235)
j. Steam Line Drain Isolation Valve (inboard) (SV-2211)
k. Consensate Pump Discharge Isolation Valve (SV-2234)
l. Steam Line Drain Isolation Valve (SV-2410)
m. Consensate Pump Discharge Isolation Valve (SV-2435)
n. Steam Line Drain Isolation Valve (SV-2411)
o. Consensate Pump Discharge Isolation Valve (SV-2436)
p. Air to Steam Pressure Reducer Valve (SV-2033)
q. Air to Steam Pressure Reducer Valve (SV-2034)
r. Air to Condenser Discharge to Suppression Pool on RCIC (SV-2037)
s. Air to Condenser Discharge to Suppression Pool on RCIC (SV-1966)
t. Air to Steam Pressure Reducer Valve (SV-1963)
u. Air to Steam Pressure Reducer Valve (SV-1964)

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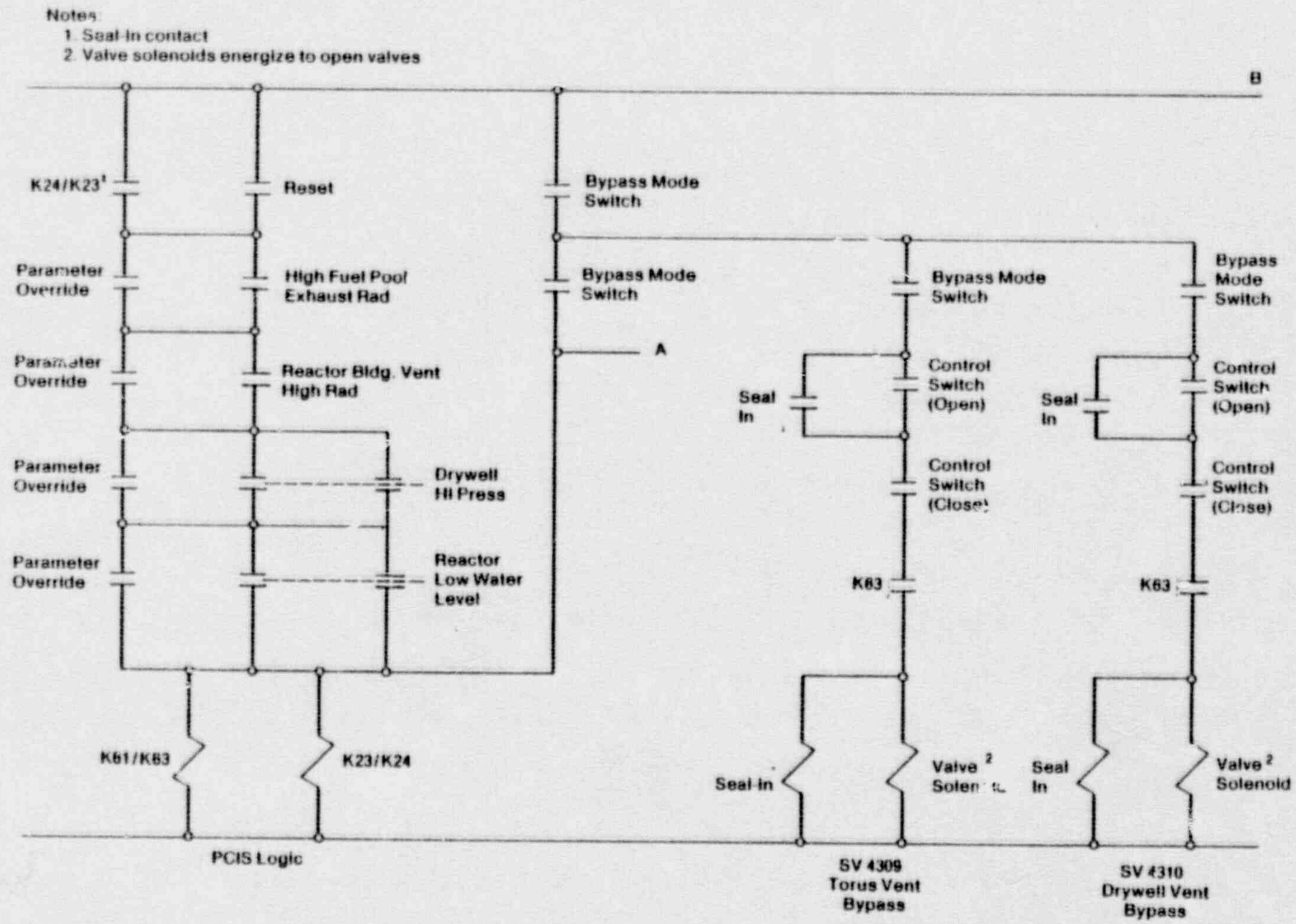

Figure 1. PCIS Control Scheme

POOR ORIGINAL

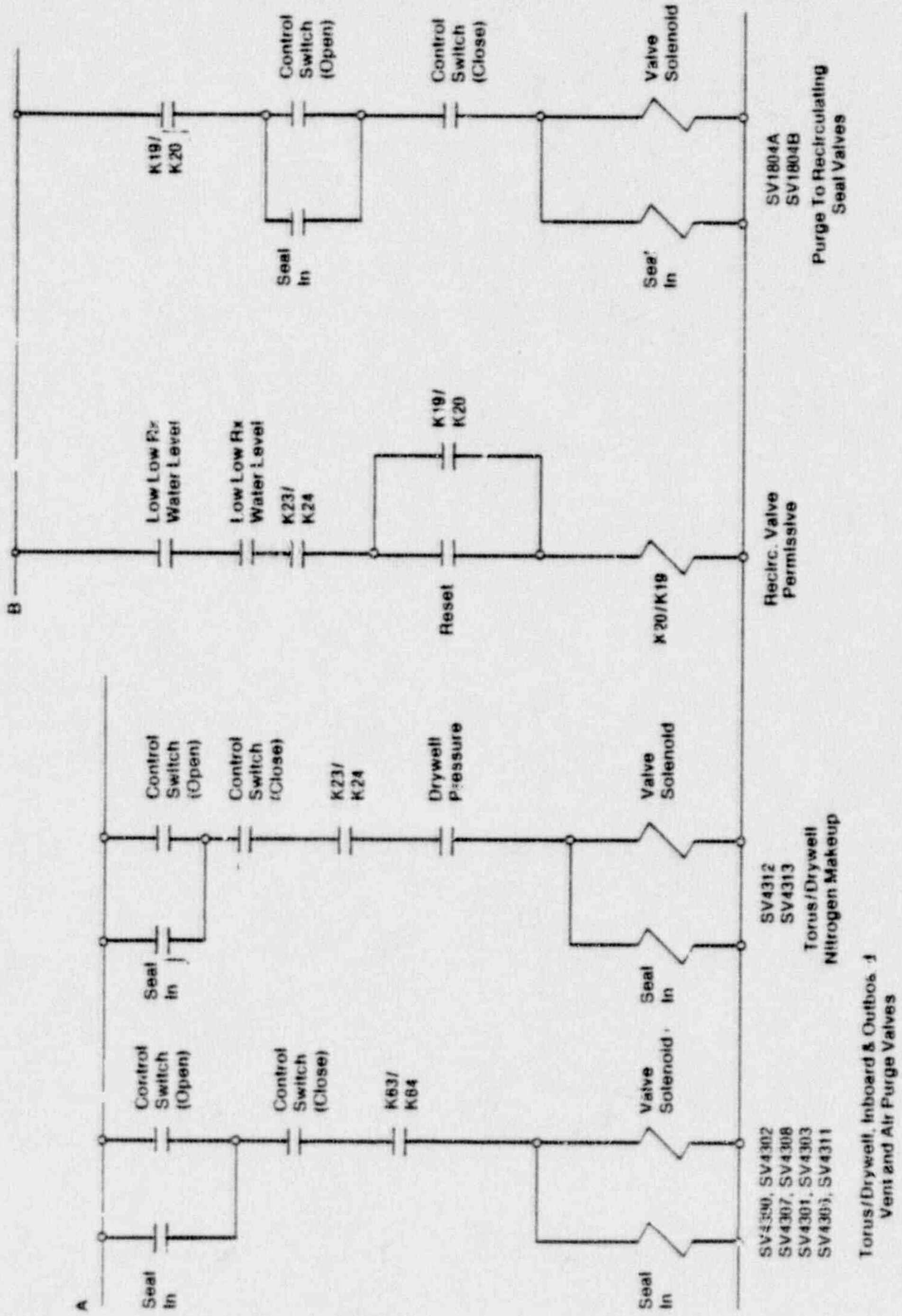

Figure 2. Typical PCIS Valve Control Circuits

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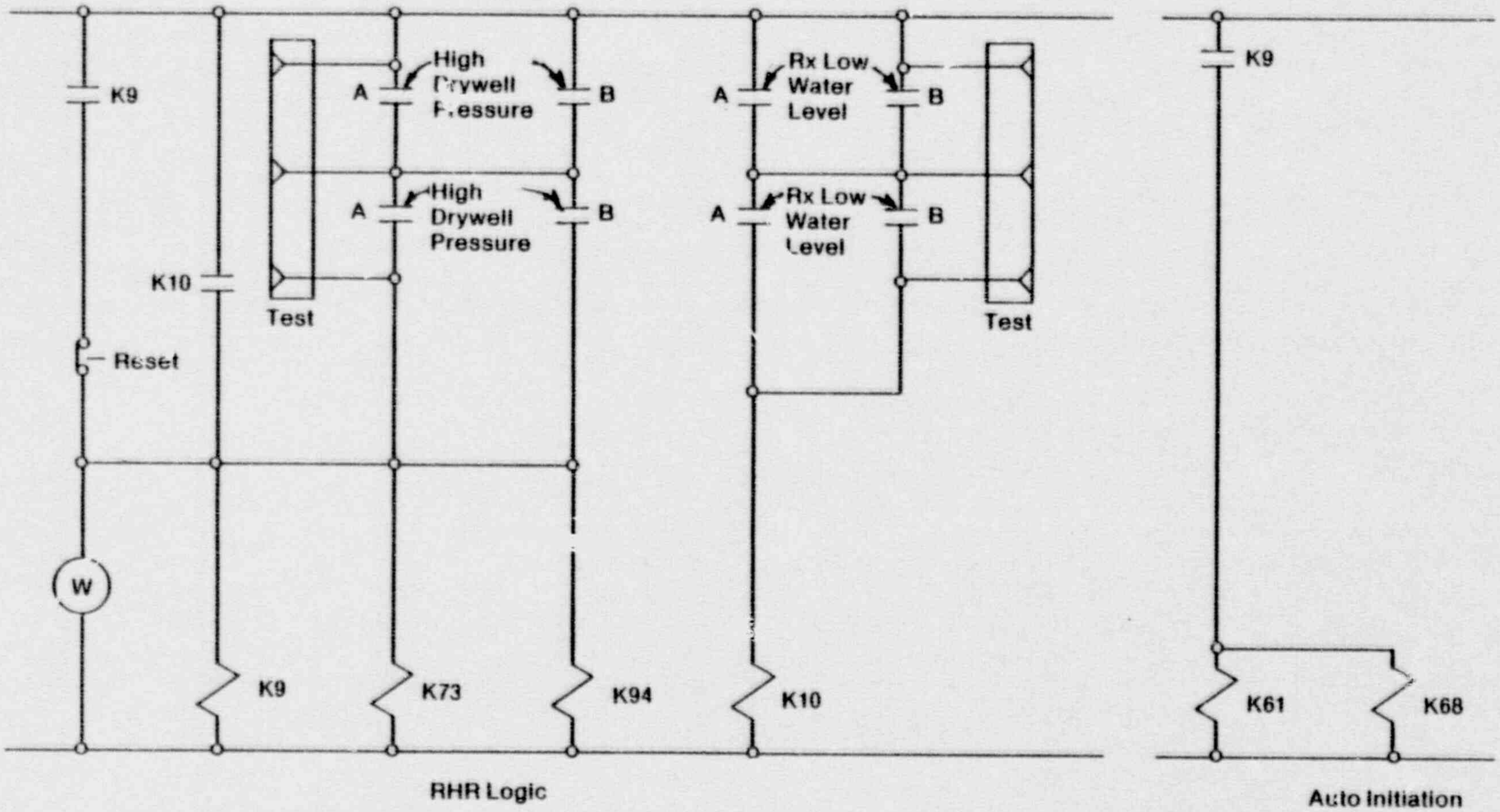


Figure 3. RHR Control Logic

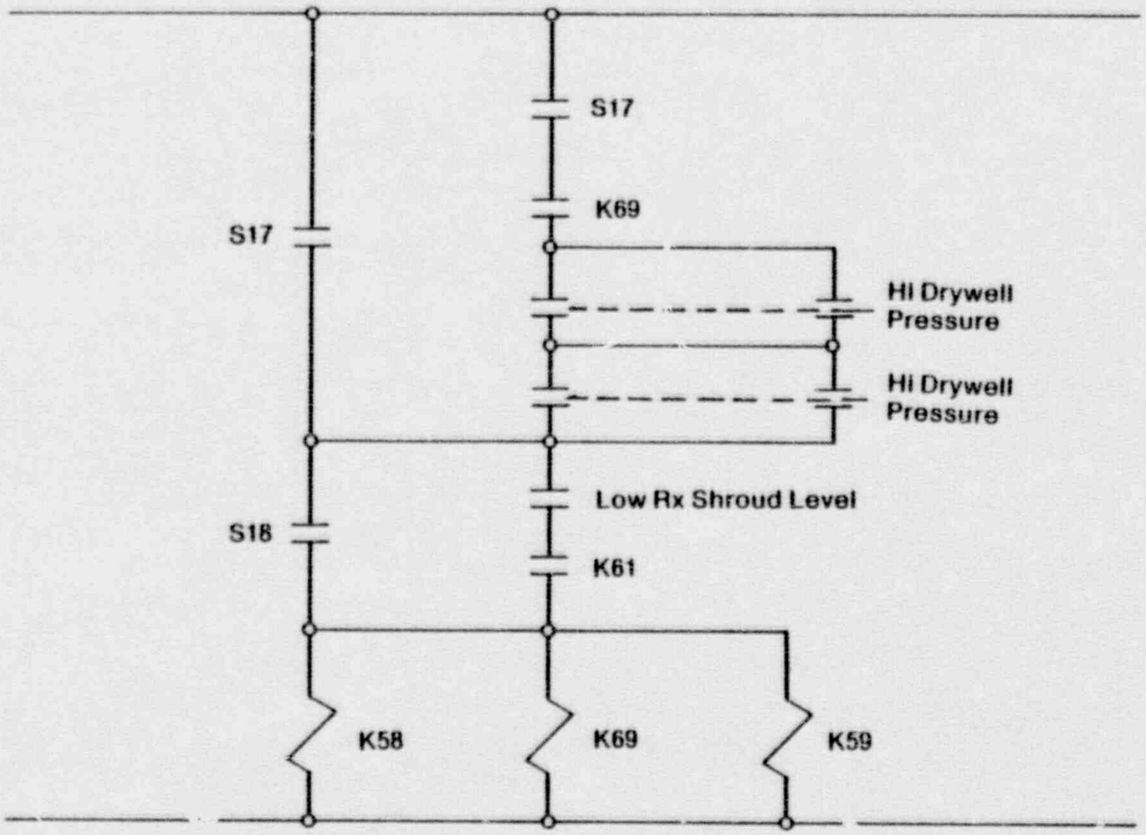
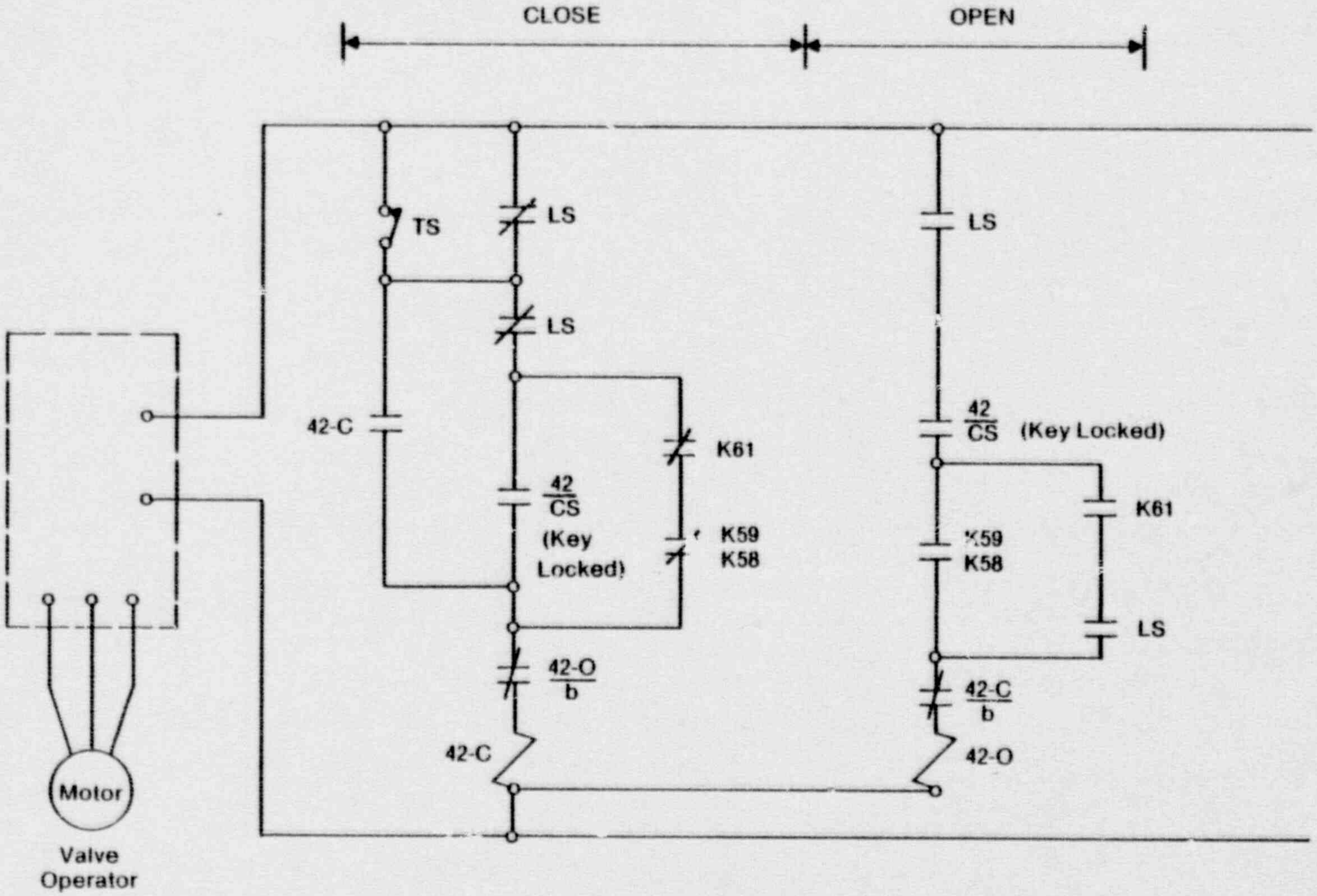


Figure 4. Containment Spray Valve Control Circuit



(MO-2000, MO-1902, MO-2005, MO-1932, MO-2001 &
MO-1903)

Figure 5. Typical RHR Valve Control Circuit

3. CONCLUSIONS

The EI&C design aspects of ESF systems for Duane Arnold were evaluated using staff design criteria.

It is concluded that the PCIS circuit design at AEC satisfies the NRC staff criteria for containment ventilation and purging operation with the exception of Criterion 4. Satisfaction of Criterion 4 will require that a radiation detector which monitors containment (i.e., drywell or torus) activity be provided and used to automatically initiate primary containment isolation.

<u>Other ESF System Circuits</u>

1. RHR System

   The RHR circuit design at DAEC satisfies the NRC staff criteria with the exception of Criterion 1 for ten valves which have functions in addition to containment isolation. These ten valves (listed in Section 2.4.2.1) may be required to provide containment spray for pressure control of the containment atmosphere in an accident environment. Opening of the valves in question requires multiple switch (keylock-type) operation, and system level annunciation is provided. In view of the possible operational requirements, administrative controls, and annunciation, FRC concludes that no modification to the RHR control circuit design is necessary.

2. Other ESF Systems

   The eight valves listed in Section 2.4.2.2 satisfy the NRC staff criteria with the exception of Criterion 1. However, because of operational requirements, these valves have functions in addition to containment isolation (i.e., post-accident reactor water sampling, nitrogen purge, and containment atmosphere sampling). Bypass of ESF actuation signals is via a keylock-type switch and is annunciated. In view of the operational considerations, administrative controls, and annunciation provided, FRC concludes that no modification to these valve control circuits is necessary.

   In the case of the 21 valves which will return to their normal, pre-accident, position upon safeguard signal reset, it is concluded that staff criteria will be satisfied upon completion of the circuit modifications identified in Attachments 2 and 3 to Reference 6.

However, until the modifications are completed, appropriate administrative controls must to instituted to ensure that all operators are aware of th.'s condition and operational procedures are established which ensure that these valves remain in their post-accident position upon system reset.

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3. L. Root (IELPCO)
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4. T. Ippolito (NRC)
   Letter to D. Arnold (IELPCO)
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5. L. Root (IELPCO)
   Letter to T. Ippolito (NRC)
   Subject: Additional Information Concerning the Electrical Design of the Containment Purge Valves
   Iowa Electric Light and Power Company, 05-05-80

6. L. Root (IELPCO)
   Letter to H. Denton (NRC)
   Subject: Electrical Aspects of Engineered Safety Features (ESF) and ESF Reset Controls
   Iowa Electric Light and Power Company, 17-06-80